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Multitude of Species Face Climate Threat

By CARL ZIMMER

Over the past 540 million years, life on Earth has passed through five great mass extinctions. In each of those catastrophes, an estimated 75 percent or more of all species disappeared in a few million years or less.

For decades, scientists have warned that humans may be ushering in a sixth mass extinction, and recently a group of scientists at the University of California, Berkeley, tested the hypothesis. They applied new statistical methods to a new generation of fossil databases. As they reported last month in the journal Nature, the current rate of extinctions is far above normal. If endangered species continue to disappear, we will indeed experience a sixth extinction, over just the next few centuries or millennia.

The Berkeley scientists warn that their new study may actually grossly underestimate how many species could disappear. So far, humans have pushed species toward extinctions through means like hunting, overfishing and deforestation. Global warming, on the other hand, is only starting to make itself felt in the natural world. Many scientists expect that as the planet's temperature rises, global warming could add even more devastation. "The current rate and magnitude of climate change are faster and more severe than many species have experienced in their evolutionary history," said Anthony Barnosky, the lead author of the Nature study.

But equally as strong as the conclusion that global warming can push extinctions is the difficulty in linking the fate of any single species to climate. Policy makers would like to get a better idea of exactly what to expect — how many species will risk extinction, and which ones are most likely to wink out of existence. But scientists who study the impact of global warming on biodiversity are pushing back against the pressure for detailed forecasts. While it's clear that global warming's impact could potentially be huge, scientists are warning that it's still impossible to provide fine-grained predictions.

"We need to stand firm about the real complexity of biological systems and not let policy makers push us into simplistic answers," said Camille Parmesan, a biologist at the University of Texas.

She and others studying climate's effects on biodiversity are calling for conservation measures that don't rely on impossible precision.

Dr. Parmesan herself has gathered some of the most compelling evidence that global warming is already leaving its mark on nature. In 2003, she and Gary Yohe, an economist at Wesleyan University, analyzed records of the geographical ranges of more than 1,700 species of plants and animals. They found that their ranges were moving, on average, 3.8 miles per decade toward the poles. Animals and plants were also moving up mountain slopes.

These were the sorts of changes you'd expect from global warming. The warmer edges of a range might become too hot for a species to survive, while the cooler edge becomes more suitable. What's more, only worldwide climate change could explain the entire pattern. "Because it's happening consistently on a global scale, we can link it to greenhouse gases changes," Dr. Parmesan said.

Dr. Parmesan and her colleagues have continued to expand their database since then. But other researchers have been moving in the opposite direction, seeking to attribute changes in individual species to climate change. Last year, for example, Michael Kearney of the University of Melbourne and his colleagues published a study on the common brown butterfly of Australia. From 1941 to 2005, adult butterflies had been emerging from their pupae 1.5 days earlier per decade around Melbourne.

To see if the brown butterfly is actually responding to climate change, Dr. Kearney and his colleagues first analyzed historical temperature records in Melbourne. Temperatures have gradually risen over the past 60 years. Computer models indicate that natural climate cycles can explain only a small part of the change.

The scientists then observed how temperature affects how brown butterflies develop. The warmer the temperature, the faster the butterflies emerged from their pupae. Dr. Kearney and his colleagues used those results to build a mathematical model to predict how long the butterflies would develop at any given temperature. They determined that Melbourne's local warming should have led to the butterflies emerging 1.5 days earlier per decade — exactly what the butterflies are, in fact, doing.

In the journal Nature Climate Change, Dr. Parmesan and her colleagues argue that trying to attribute specific biological changes to global warming is the wrong way to go. While the global fingerprint of climate change may be clear, the picture can get blurry in individual species. "When

you go to the local level, the outcome of climate change on one particular species is not dependent just on what climate change is doing," said Dr. Parmesan.

In Europe, for example, the map butterfly has expanded its range at both its northern and its southern edge. Global warming probably has something to do with its northern expansion. But the butterflies are also benefiting from the mowing of roadsides, which allows more nettle plants to grow. Because map butterflies feed on nettles, they're able to survive across a broader range of Europe.

A number of experts applaud the commentary from Dr. Parmesan and her colleagues. "I think they really hit the nail on the head," said Richard Pearson, the director of biodiversity informatics research at the American Museum of Natural History. "Biologists shouldn't get drawn heavily into the attribution debate."

But some researchers counter that such studies can be worthwhile cases where global warming's impact on an individual species is clear. "The fact that the task may simply be too challenging in most cases does not mean that it will be impossible or a waste of effort in some particular cases," said Dáithí Stone, a climate scientist at the University of Cape Town in South Africa.

Tracking the effects of climate change on species today can help show how nature may respond to it in decades to come. And many scientists think that the future looks grim. As temperatures rise, many species may not be able to shift their ranges to stay in a comfortable environment. Instead, their ranges may shrink, pushing them toward extinction.

Over the past decade, Dr. Pearson and other researchers have developed models to predict these future range shifts. They typically calculate the "climate envelope" in which species live today, and then use global warming projections to find where their climate envelopes will be in the future.

These models first came to prominence in 2004, when an international team of scientists published a study of more than a thousand species. They estimated that 15 percent to 37 percent of all species could become "committed to extinction" by 2050, thanks to climate change.

"It was a big splash for the field," recalled Dr. Pearson. But in his new book, "Driven to Extinction," Dr. Pearson recounts how he cringed to see the research boiled down to simple, stark headlines that said a million species were doomed.

"Biodiversity is under severe threat from climate change, but we need to be careful that we don't give a false impression of what our confidence is," said Dr. Pearson. "We have to give a nuanced

sense of what we do know and what we can say with confidence."

Seven years after the million-species headlines, Dr. Pearson says that extinction models still have a long way to go. "We've made some incremental improvements, but I don't think they're hugely better," he said.

"It's been a very powerful tool, but my concern is that it's very weak on biology," said Georgina Mace of Imperial College London. In the latest issue of Science, she and her colleagues use the fossil record to demonstrate how seemingly similar species can respond in different ways to climate change.

When the planet warmed at the end of the ice age 11,000 years ago, for example, the change was too much for Irish elk, which became extinct. Moose, on the other hand, have survived. Some moose populations stayed put; other populations shifted to more suitable places.

Dr. Mace and her colleagues call for new models that can assess the sensitivity of species to climate, as well as their ability to adapt. In some cases, that adaptation may be evolution. Species may become better able to tolerate warmer temperatures or a change in rainfall. In other cases, animals may adapt by changing their behavior.

Polar bears, for example, are having a harder time hunting seals because of melting sea ice. "They don't say, we can't eat seals anymore, so we're just going to starve," Dr. Pearson said. Instead, some bears are getting more food on land, raiding goose nests for their eggs.

While this switch may slow the decline of polar bears, it's not great news for the geese. Dr. Pearson notes that all the influences that species have on one another will also determine how climate change affects them. "Predicting how communities will respond is really tricky," he said.

Dr. Mace argues that a fuller accounting of how species cope with climate could let scientists revise their estimate for how many species could become extinct. "I think it could be a lot worse for some groups of species, and not as bad for others," she said.

Humans add even more complexity to the forecast. Cities and farms now block the path for many species that might otherwise be able to spread to more suitable habitats, for example. Dr. Parmesan thinks much more research should go into the interactions of global warming and other human impacts. Scientists in Australia have found that coral reefs are more resilient against global warming, for example, if they're protected from overfishing. The warming oceans stimulate the growth of deadly algae on the reefs. But grazing fish can keep the algae in check.

Such research will become the basis for decisions about which species to help, and how. Dr. Mace believes that some especially vulnerable species may need to be moved to new habitats in order to survive. Dr. Parmesan thinks that reducing other pressures, like overfishing, will make species more resilient to climate change. “We know that climate change wouldn’t be such a big problem if systems weren’t already stressed,” Dr. Parmesan said. “We really need to focus on reducing these other stressors.”

Dr. Pearson, on the other hand, argues for setting aside more land in parks and reserves. More space will help keep species ranges large even if those ranges shift.

“We need to give nature the opportunity to respond,” he said.